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(54) Abstract Title
Vehicle propulsion control in response to braking

(57) A vehicle 10 has an engine management system (EMS) 22 for controlling an engine 12 and a braking system 28 for slowing the vehicle 10 down. When the brake pedal 30 is applied, the EMS 22 progressively ramps down the engine torque in a tuneable manner, regardless of any torque demand signal from the accelerator pedal demand potentiometer 26. The EMS 22 includes an inclinometer 38 and selectively reduces or abandons the restriction of torque output from the prime mover 12 in response to the inclinometer signal so as, for example, to assist in hill starts. Torque control may be reducing fuel or air supply, or change of ignition timing. Alternatively, for electric vehicles, power to the motor vehicles is reduced. Torque output restriction may itself be limited or abandoned in response to a time delay, gear change or halting of the vehicle.

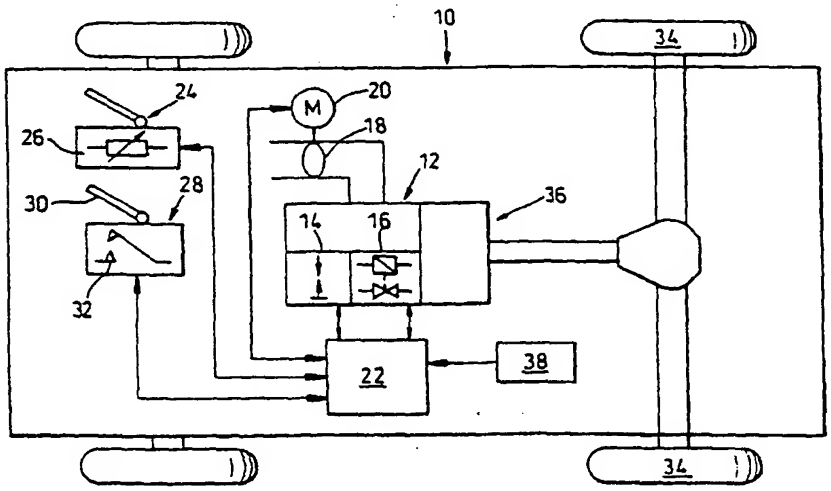

Fig. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

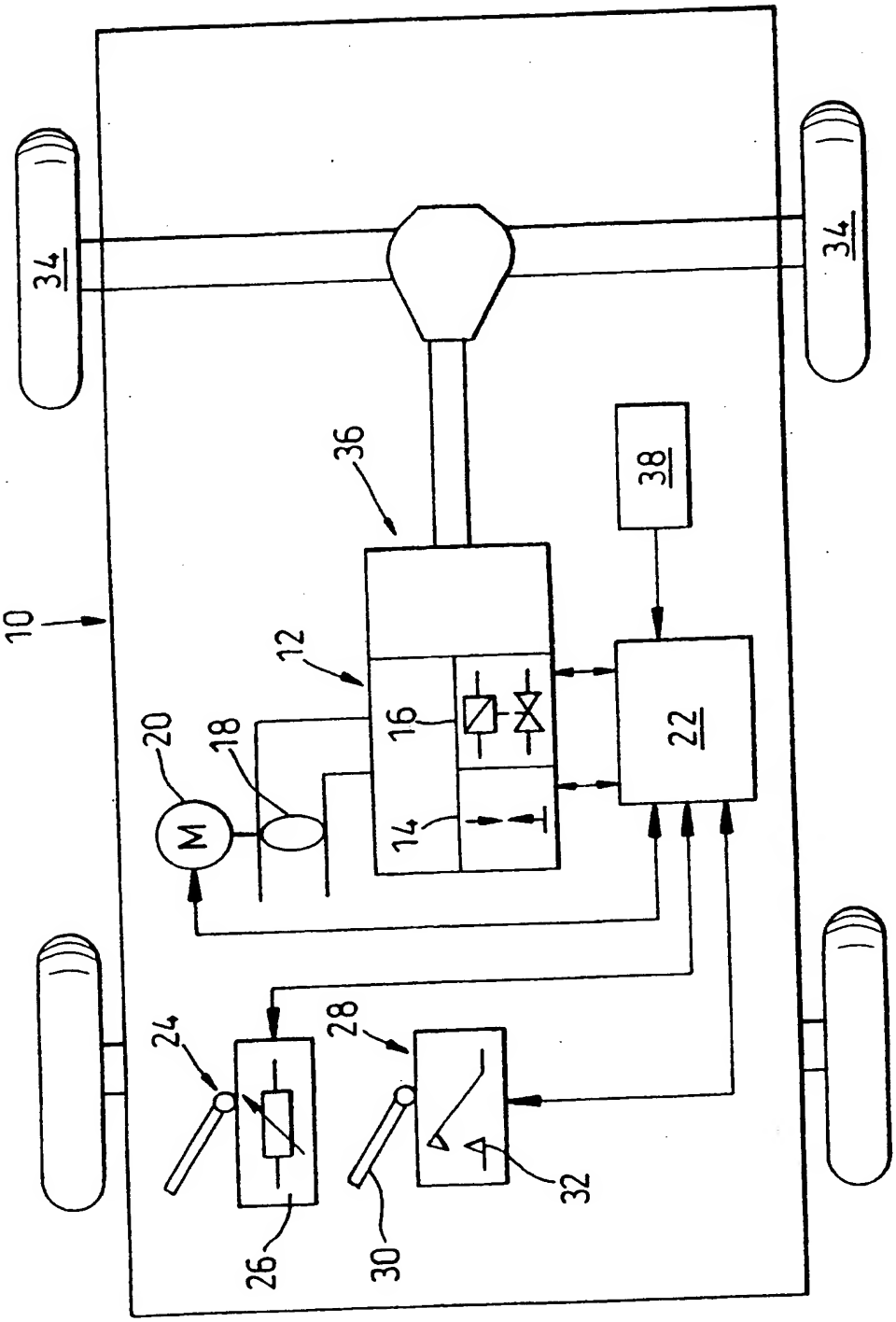

Fig. 1

A Control System for a Vehicle

This invention relates to control systems for vehicles and in particular to: a control system which controls the torque output of a prime mover of a vehicle; a control means for use in such a control system; a method of controlling such a control system; and to a vehicle including such a control system.

It is known to provide a vehicle with a prime mover, such as an engine, having a prime mover control system which controls the torque output of the prime mover. It is a known problem with some prior art systems for the torque output of the prime mover to remain at a high level even when a brake pedal is depressed. For example, such a case could arise if there were to be a fault in a pedal demand potentiometer forming part of an accelerator pedal of a drive-by-wire system, which might then indicate a continued acceleration demand signal even after the accelerator pedal had been released and the brake pedal had been depressed. A continued delivery of torque from the prime mover would act in opposition to the braking demand and reduce the efficiency of the vehicle braking system.

It is known from US 4,987,872 to provide a system which monitors accelerator and brake pedal positions and reduces the power output of the

engine by cutting off the air and or fuel supply if the throttle sticks open or if the brake pedal is depressed at the same time as the throttle.

There are times, however, when it is desirable to have both the accelerator pedal and the brake pedal depressed simultaneously, for example during hill starts. The system of US 4,987,872 might interpret such hill starts as a fault condition and assume that the accelerator was stuck open. It would then reduce the torque, making such hill starts more difficult.

It is an object of this invention to provide: an improved control system which controls the torque output of a prime mover of a vehicle; a control means for use in such a control system; a method of controlling such a control system; and a vehicle including such a control system.

According to the invention there is provided a control system for a vehicle comprising a prime mover control means arranged in use to control the output of torque from a prime mover in response to a torque demand signal from a torque demand means and a brake actuation means arranged in use to control the braking of the vehicle in response to a braking demand from a braking demand means, the prime mover control means being arranged to over-ride the torque demand signal and to restrict the torque output of the prime mover in response to the braking demand, wherein the

prime mover control means further comprises an inclinometer arranged in use to provide an inclination signal indicative of an inclination of the vehicle and the prime mover control means is arranged to selectively reduce or abandon the restriction of torque output in response to said inclination signal.

The prime mover control means may be arranged to reduce or abandon the restriction of torque output when the vehicle is pointing up an incline of at least a predetermined angle.

The prime mover control means may be arranged to reduce or abandon the restriction of torque output when the vehicle is pointing down an incline of at least a predetermined angle.

The prime mover control means may be arranged to reduce or abandon the restriction of torque output when a low transmission ratio of the vehicle has been selected.

The prime mover control means may be arranged to reduce or abandon the restriction of torque output when a reverse transmission output ratio of the vehicle has been selected.

The prime mover control means may be arranged to reduce or abandon the restriction of torque output when the vehicle is stationary or travelling at a low speed.

The prime mover control means may be arranged to reduce or abandon the restriction of the torque output by a progressive variation with time in the supply of a power source to the prime mover.

The prime mover control means may be arranged to reduce or abandon the restriction of torque output for only a preset period.

The invention also provides a prime mover control means for use in a control system according to the invention and also provides a vehicle including a control system according to the invention.

The invention still further provides a method of controlling a control system for a vehicle comprising a prime mover control means arranged in use to control the output of torque from a prime mover in response to a torque demand signal from a torque demand means and a brake actuation means arranged in use to control the braking of the vehicle in response to a braking demand from a braking demand means, the prime mover control means being arranged to over-ride the torque demand signal and to restrict

the torque output of the prime mover in response to the braking demand, the method including the steps of:

a) providing to the prime mover control means from an inclinometer an inclination signal indicative of an inclination of the vehicle; and

b) reducing or abandoning selectively the restriction of torque output in response to said inclination signal.

The method may include reducing or abandoning the restriction of torque output when the vehicle is pointing up an incline of at least a predetermined angle.

The method may include reducing or abandoning the restriction of torque output when the vehicle is pointing down an incline of at least a predetermined angle.

The method may include reducing or abandoning the restriction of torque output when a low transmission ratio of the vehicle has been selected.

The method may include reducing or abandoning the restriction of torque output when a reverse transmission output ratio of the vehicle has been selected.

The method may include reducing or abandoning the restriction of torque output by progressively varying the supply of a power source to the prime mover.

The method may include reducing or abandoning the restriction of torque output for only a preset period.

The invention will now be described by way of example with reference to the accompanying drawing, in which:

Figure 1 is a schematic diagram of a vehicle having a control system according to the invention.

Referring to the figure, a vehicle 10 comprises a prime mover in the form of a spark ignition engine 12 having an ignition system 14 and a fuelling system comprising a fuel injection means 16 and a throttle butterfly 18 driven by a motor 20.

The vehicle 10 further comprises a prime mover control means in the form of an engine management system (EMS) 22 which controls the ignition system 14 and the fuelling system 16, 18, 20 to regulate the torque produced by the engine 12 which is used to drive a set of wheels 34 through a transmission 36.

The EMS 22 is connected to a drive-by-wire accelerator pedal 24 which acts as an engine torque demand means and includes a throttle demand potentiometer 26. The potentiometer 26 detects how far the accelerator pedal 24 has been depressed and provides an electrical signal to the EMS 22 indicating how much torque is demanded, there being no mechanical connection between the accelerator pedal 24 and the engine 12.

The vehicle 10 further comprises a brake actuation means in the form of a hydraulic braking system 28 which is arranged to brake the wheels 34 in response to use of a brake pedal 30. The braking system 28 includes a conventional brake switch 32 which is connected to a pair of rear mounted brake lights (not shown) and also in parallel to the EMS 22. The brake switch 32 makes on use of the brake pedal 30 and provides power to the brake lights and at the same time also provides the EMS 22 with a braking demand signal which indicates operation of the brakes.

When the EMS 22 receives the braking demand signal, it over-rides any torque demand signal from the potentiometer 26 and reduces the torque produced by the engine 12 all the time that the braking demand signal is present.

The EMS 22 is programmed to reduce the torque progressively to the minimum output necessary to maintain an engine idle speed which can keep

the engine 12 running and sustain the ancillary services supplied by it, such as an air conditioning system or a power steering system (not shown).

To reduce the torque progressively, the EMS 22 calculates the fuelling and ignition settings necessary to achieve the idle speed and compares the projected idle speed settings with the existing fuelling and ignition settings being applied when the braking demand signal is received. The EMS 22 then calculates the changes to the existing settings necessary to achieve the idle speed settings within a pre-determined and pre-programmed time t. The EMS 22 then reduces the torque in steps at a rate which will achieve the idle speed by the time t.

The torque output is reduced in this embodiment by using one or more of three techniques selected from a look-up table programmed in the EMS 22, the selection being made in a tuneable manner depending on the instant running conditions of the engine 12. The three methods of reducing torque are: by a stepped reduction of the quantity of fuel supplied to the cylinders of the engine 12 by the fuel injection system 16 on successive injection pulses; by the EMS 22 controlling the motor 20 to partially or fully close the throttle butterfly 18 and thereby to restrict the supply of air to the engine 12; and by controlling the ignition system 14 to retard the spark timing in steps on successive ignition pulses.

The initiation of the torque restriction may be delayed for a short period after the braking demand signal is detected at the EMS 22, e.g. for one to two seconds, to allow for correct use of left foot braking during normal driving. Such a situation might arise, for example, with a vehicle 10 having an automatic transmission 36 when the driver is performing a hill-start or when pulling away from stationary while towing, in either of which cases it may be useful to hold the vehicle 10 on the foot brake pedal 30 and to use the accelerator 24 to build up torque output before releasing the brake pedal 30.

The braking demand signal used by the EMS 22 to initiate the torque reduction may be derived directly from the brake switch 32 or may be supplied by the braking system 28. The only requirement is for the EMS 22 to detect when the driver wishes to brake the vehicle 10 in order that the EMS 22 may start reducing the engine torque.

The reduction in engine torque prevents a reduction in efficiency of the braking system 28 in retarding the vehicle 10, regardless of any signal from the pedal demand potentiometer 26 and thereby significantly reduces the likelihood of an unintentional acceleration of the vehicle 10, either through component failure of the torque demand means or through driver error.

An inclinometer 38 is provided which is arranged to supply a signal to the EMS 22 indicative of the inclination of the vehicle fore-aft axis with respect to the horizontal. It is known to provide a vehicle with an inclinometer from US 5,667,282.

The inclinometer signal is used by the EMS 22 to selectively reduce or abandon the restriction of torque output from the prime mover when the vehicle 10 is on an incline and torque restriction is calculated as undesirable.

A pre-determined angle of incline at which torque restriction is calculated as undesirable is programmed into the EMS 22 and depends on the characteristics of the particular vehicle 10. It includes, for example, factors such as gross weight and whether or not it is used for towing.

One example of a situation when torque restriction is reduced or abandoned as a result of an inclinometer signal is when the vehicle 10 is pointing up an incline and left foot braking is used to assist with pulling away uphill. To ensure safety is not compromised, interlocks are included using additional sensors (not shown) to ensure that the torque restriction is not disabled outside pre-set safety parameters, e.g. only disabling the feature if the vehicle 10 is in a low transmission output ratio and / or

travelling at zero or low speed (such as below a speed in the order of 10 kph).

A second example of a situation when torque restriction is reduced or abandoned as a result of an inclinometer signal is when the vehicle 10 is pointing down an incline, is in a reverse ratio and left foot braking is used to assist with pulling away uphill. Such a situation might arise, for example, during a parking manoeuvre on a hill.

In order to reduce or abandon the torque output restriction, the EMS 22 progressively varies the supply of a power source to the engine. The power source comprises one or more of fuelling, air or ignition and is varied using the similar techniques to those described above for the torque restriction but applied *mutatis mutandis* to raise the torque output rather than lower it.

In a modification to the invention, the reduction or abandonment of the restriction of torque output is only performed for a predetermined period, for example 5 seconds. This feature ensures that the system will firstly give ample time for left foot braking during hill starts and then provide the torque output restriction after a preset delay. In this manner, the system takes account of the possibility of an accelerator sticking but the fault being permanently ignored on hills because of the presence of an inclinometer signal. The system will therefore fail safe.

This invention is not restricted to vehicles having an internal combustion engine 12 as a prime mover and could equally be applied to another type of prime mover, such as an electric traction motor. The torque restriction feature would, in that case, reduce the power supply to the motor to reduce torque and might additionally, or in the alternative, use regenerative braking to reduce the driving torque to the wheels while a brake demand signal were present. In this case, the reduction or abandonment of torque restriction in response to a predetermined inclinometer signal would, for example, be achieved by progressively increasing the supply of electrical power to the traction motor with a corresponding decrease in regenerative braking.

CLAIMS

1. A control system for a vehicle comprising a prime mover control means arranged in use to control the output of torque from a prime mover in response to a torque demand signal from a torque demand means and a brake actuation means arranged in use to control the braking of the vehicle in response to a braking demand from a braking demand means, the prime mover control means being arranged to over-ride the torque demand signal and to restrict the torque output of the prime mover in response to the braking demand, wherein the prime mover control means further comprises an inclinometer arranged in use to provide an inclination signal indicative of an inclination of the vehicle and the prime mover control means is arranged to selectively reduce or abandon the restriction of torque output in response to said inclination signal.

2. A control system according to Claim 1, wherein the prime mover control means is arranged to reduce or abandon the restriction of torque output when the vehicle is pointing up an incline of at least a predetermined angle.

3. A control system according to Claim 1 or Claim 2, wherein the prime mover control means is arranged to reduce or abandon the restriction of

torque output when the vehicle is pointing down an incline of at least a predetermined angle.

4. A control system according to any preceding claim, wherein the prime mover control means is arranged to reduce or abandon the restriction of torque output when a low transmission ratio of the vehicle has been selected.

5. A control system according to any preceding claim, wherein the prime mover control means is arranged to reduce or abandon the restriction of torque output when a reverse transmission output ratio of the vehicle has been selected.

6. A control system according to any preceding claim, wherein the prime mover control means is arranged to reduce or abandon the restriction of torque output when the vehicle is stationary or travelling at a low speed.

7. A control system according to any preceding claim, wherein the prime mover control means is arranged to reduce or abandon the restriction of the torque output by a progressive variation with time in the supply of a power source to the prime mover.

8. A control system according to any preceding claim, wherein the prime mover control means is arranged to reduce or abandon the restriction of torque output for only a preset period.

9. A control system substantially as described herein with reference to the accompanying drawing.

10. A prime mover control means for use in a control system according to any preceding claim.

11. A vehicle including a control system according to any one of Claims 1 to 9.

12. A method of controlling a control system for a vehicle comprising a prime mover control means arranged in use to control the output of torque from a prime mover in response to a torque demand signal from a torque demand means and a brake actuation means arranged in use to control the braking of the vehicle in response to a braking demand from a braking demand means, the prime mover control means being arranged to over-ride the torque demand signal and to restrict the torque output of the prime mover in response to the braking demand, the method including the steps of:

a) providing to the prime mover control means from an inclinometer an inclination signal indicative of an inclination of the vehicle; and

b) reducing or abandoning selectively the restriction of torque output in response to said inclination signal.

13. A method according to Claim 12, including reducing or abandoning the restriction of torque when the vehicle is pointing up an incline of at least a predetermined angle.

14. A method according to Claim 12 or Claim 13, including reducing or abandoning the restriction of torque output when the vehicle is pointing down an incline of at least a predetermined angle.

15. A method according to any one of Claims 12 to 14, including reducing or abandoning the restriction of torque output when a low transmission ratio of the vehicle has been selected.

16. A method according to any one of Claims 12 to 15, including reducing or abandoning the restriction of torque output when a reverse transmission output ratio of the vehicle has been selected.

17. A method according to any one of Claims 12 to 16, including reducing or abandoning the restriction of torque output by progressively varying the supply of a power source to the prime mover.

18. A method according to any one of Claims 12 to 17, including reducing or abandoning the restriction of torque output for only a preset period.

19. A method substantially as described herein with reference to the accompanying drawing.